High Energy Micro-Diffraction

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Many natural and technologically important interfaces lie deeply buried beneath their exposed surfaces. In order to access them with a non-destructive technique, an in situ probe with the potential for molecular-scale resolution is required. High-energy x-ray micro beams are the ideal probe due to their large penetration power, thereby making a wide variety of buried interfaces accessible for structural studies. The basic principle exploits the large penetration of high-energy x-rays at low angles so that only the one interface of interest is illuminated with x-rays. This reduces the number of interfaces that contribute to the scattered signal and enables the use of two general techniques, x-ray reflectivity and grazing-incidence diffraction, on interfaces that are otherwise inaccessible. It has turned out that the very small size of the incident beam, as required for small incident angles at high energies, also serves to reduce the background, giving access to molecular or even atomic resolution in most cases.

Any information encoded within the diffraction signal can be used to reconstruct 2D or 3D representations of the state of a sample providing much more physically and chemically relevant information than conventional tomographic techniques based on electron density variations alone. Thanks to recent advances in high-energy x-ray production, focusing and detection, time-resolved diffraction tomography experiments are now possible. This has been most prominently employed for the study of the evolution of industrial catalysts undergoing a thermal treatment as a route to the formation of the active phase. The obtained results constitute a new way of monitoring intricate chemistry in space and time within materials.